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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/016,255	12/10/2001	Peijun Ding	AMAT/2859.C1/CPI/COPPER/P	7901

32588 7590 08/06/2003

APPLIED MATERIALS, INC.
2881 SCOTT BLVD. M/S 2061
SANTA CLARA, CA 95050

EXAMINER

MCDONALD, RODNEY GLENN

ART UNIT	PAPER NUMBER
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1753

DATE MAILED: 08/06/2003

Please find below and/or attached an Office communication concerning this application or proceeding.

Office Action Summary

Application No.

10/016,255

Applicant(s)

DING ET AL.

Examiner

Rodney G. McDonald

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-- The MAILING DATE of this communication appears on the cover sheet with the corresponding address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If the period for reply specified above is less than thirty (30) days, a reply within the statutory minimum of thirty (30) days will be considered timely.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133).
- Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☐ Responsive to communication(s) filed on ____.
- 2a) ☐ This action is FINAL. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-26 is/are pending in the application.
- 4a) Of the above claim(s) ____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) ____ is/are allowed.
- 6) ☒ Claim(s) 1-26 is/are rejected.
- 7) ☐ Claim(s) ____ is/are objected to.
- 8) ☐ Claim(s) ____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on ____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
- 11) ☐ The proposed drawing correction filed on ____ is: a) ☐ approved b) ☐ disapproved by the Examiner.
If approved, corrected drawings are required in reply to this Office action.
- 12) ☐ The oath or declaration is objected to by the Examiner.

Priority under 35 U.S.C. §§ 119 and 120

- 13) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
2. ☐ Certified copies of the priority documents have been received in Application No. ____.
3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).
* See the attached detailed Office action for a list of the certified copies not received.
- 14) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. § 119(e) (to a provisional application).
a) ☐ The translation of the foreign language provisional application has been received.
- 15) ☐ Acknowledgment is made of a claim for domestic priority under 35 U.S.C. §§ 120 and/or 121.

Attachment(s)

- 1) ☒ Notice of References Cited (PTO-892)
- 2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
- 3) ☒ Information Disclosure Statement(s) (PTO-1449) Paper No(s) 2,3.
- 4) ☐ Interview Summary (PTO-413) Paper No(s). ____.
- 5) ☐ Notice of Informal Patent Application (PTO-152)
- 6) ☐ Other:

DETAILED ACTION

Claim Rejections - 35 USC § 102

The following is a quotation of the appropriate paragraphs of 35 U.S.C. 102 that form the basis for the rejections under this section made in this Office action:

A person shall be entitled to a patent unless –

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for a patent.

Claims 1-5, 11-14, 17 and 19-23 are rejected under 35 U.S.C. 102(a) as being anticipated by Chiang et al. (WO 98/54377).

Chiang teach depositing a Ta or TaN barrier layer for use in combination with copper in a semiconductor interconnect structure. The improvement comprises depositing a Ta or TaN barrier layer at a substrate temperature of at least 300 degrees C, preferably within a temperature range of about 300 degrees C to about 500 degrees C, prior to deposition of copper on a substrate. (Page 5 lines 10-15) Ion metal plasma sputter deposition in the film deposition method. (Page 4 lines 3-4) The pressure during the IMP of Ta or TaN can be 40 mTorr. (page 19 line 1) The resistivity of the Gamma TaN can range from about 100 to 250 microohms-cm. (See Figure 4) The resistivity of the IMP-TaN can range from about 80 to 200 microohms-cm. (See Figure 5)

A thin continuous wetting layer of copper (compare to Applicant's required seed layer) is applied to the substrate surface. The wetting layer thickness (on the wall of the trench or via) should be a minimum of about 50 Angstroms, and typically may be about 100 Angstroms to 300 Angstroms. (Page 11 lines 1-11)

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The copper sputtering technique can be IMP copper. (Page 11 lines 19-21)

The films can undergo a 30 minute anneal at a temperature of 600 degrees C. However annealing films deposited at room temperature will not improve the barrier performance of the films. (Page 23 lines 11-13)

Reducing the residual stress in the TaN film is beneficial for the execution of subsequent process steps without delamination of such films from trench and via sidewalls or other interconnect features. (Page 3 lines 7-12) Figures 5 and 7 show the correlation between resistivity and stress based on nitrogen flow rate. A nitrogen flow rate of about 5 sccm produces the best result. (See Figures 5 and 7)

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

Claims 1-5, 11-14 and 17-23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chiang et al. (WO 98/54377).

Chiang et al. is discussed above and all is as applies above. (See Chiang et al. discussed above)

The differences between Chiang and the present claims is that the range of the resistance is not discussed, the seed layer thickness is not discussed and the anneal temperature being about 450 degrees C to 500 degrees C is not discussed.

As to the range of resistances and the seed layer thicknesses, the subject matter as a whole would have been obvious to one of ordinary skill in the art at the time the invention was made to have selected the overlapping portion of the range disclosed by Chiang et al. because overlapping ranges have been held to be a prima facie case of obviousness, see In re 182 U.S.P.Q. 549.

As to the anneal temperature "about" 600 degrees C suggests "about" 500 degrees C.

The motivation for selecting the lower resistances in the range is the it will allow for films with lower stress which in turn will be beneficial for the execution of subsequent process steps without delamination of such films from trench and via sidewalls or other interconnect features. (See Page 3 lines 7-12) The motivation for selecting the thickness of 250 to 300 angstroms is that thickness allows filling of a hole with a specific feature size and aspect ratio. (Page 11 lines 1-11)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Chiang et al. by utilizing a selected

resistance and selected wetting layer thickness is that it will allow for preventing delamination of the film and filling a hole with a specific feature size and aspect ratio.

Claim 15 is rejected under 35 U.S.C. 103(a) as being unpatentable over Chiang et al. as applied to claims 1-5, 11-14 and 17-23 above, and further in view of Ho et al. (U.S. Pat. 5,354,712) and Ngan et al. (EP 0 867 525).

The difference not yet discussed is utilizing a TiN barrier layer.

Ho et al. teach utilizing as the barrier layer before copper deposition TiN. Ho et al. also recognizes that instead of TiN tantalum can be utilized for the barrier layer. (Column 10 lines 40-52)

The motivation for selecting TiN as a barrier layer is that it prevents interfacial diffusion across the contact region. (Column 10 lines 40-52)

Ngan et al. teach a TiN barrier film deposited by IMP with a resistivity less than 60 microOhm-cm. (see Abstract)

The motivation for having a TiN layer with low resistivity is that the TiN film may need to serve as a main conductive path for the interconnect. (Column 2 lines 41-45)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have utilized TiN as the barrier layer as taught by Ho et al. and Ngan et al. because it allows for preventing interfacial diffusion across the interface and providing a conductive path.

Claims 16 and 24-26 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chiang et al. as applied to claims 1-5, 11-14 and 17-23 above, and further in view of Chittipeddi et al. (U.S. Pat. 5,972,179).

The differences not yet discussed are the use of a multilayer stack as the barrier layer and the deposition of the multilayer stack by CVD and PVD.

Chittipeddi et al. teach a composite TiN barrier layer structure formed by depositing a first TiN layer by CVD to obtain good step coverage, followed by a second TiN layer formed by PVD to obtain uniform surface morphology. (See abstract)

The motivation for first depositing a TiN layer by CVD and then a TiN layer by PVD is that it allows obtaining uniform surface morphology. (See Abstract)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have utilized a multilayer stack and to have deposited the multilayer stack by first depositing by CVD and then PVD as taught by Chittipeddi et al. because it allows for controlling the surface morphology of the barrier layer.

Claims 6-10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Chittipeddi et al. (U.S. Pat. 5,972,179) in view of Ngan et al. (EP 0 867 525).

Chittipeddi et al. teach depositing TiN barrier layer by CVD then depositing a TiN barrier layer by PVD. (See Abstract) The CVD TiN layer is about 50-600 Angstroms in thickness. (Column 3 lines 66) The PVD TiN layer is about 100-400 Angstroms in thickness. (Column 4 lines 13-14) The temperature during PVD can be 100-400 degrees C. (Column 4 line 5)

The differences between Chittipeddi et al. and the present claims is that the resistance is not discussed, utilizing a high density plasma physical vapor deposition process for the second barrier layer, the pressure during PVD is not discussed.

Ngan teach IMP deposition of a TiN film having a resistivity of less than 60 microhm-cm. (See Abstract) The pressure during deposition of the TiN can be 32 mTorr. (Column 10 lines 34)


The motivation for utilizing a high density PVD process such as IMP as a low pressure to produce a film of low resistivity is that a low resistivity film may need to serve as a conductive path with a lengthened performance lifetime. (Column 2 lines 41-58; Column 3 lines 1-7)

Therefore, it would have been obvious to one of ordinary skill in the art at the time the invention was made to have modified Chittipedi et al. by utilizing a high density PVD process such as IMP to produce the sputter deposited TiN film with low resistivity as taught by Ngan because it allows for producing a film with lengthened performance lifetime.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Rodney G. McDonald whose telephone number is 703-308-3807. The examiner can normally be reached on M- Th with Every other Friday off.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Nam X. Nguyen can be reached on 703-308-3322. The fax phone numbers for the organization where this application or proceeding is assigned are 703-872-9310 for regular communications and 703-872-9310 for After Final communications.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is 703-308-0661.


Rodney G. McDonald
Primary Examiner
Art Unit 1753

RM
August 4, 2003